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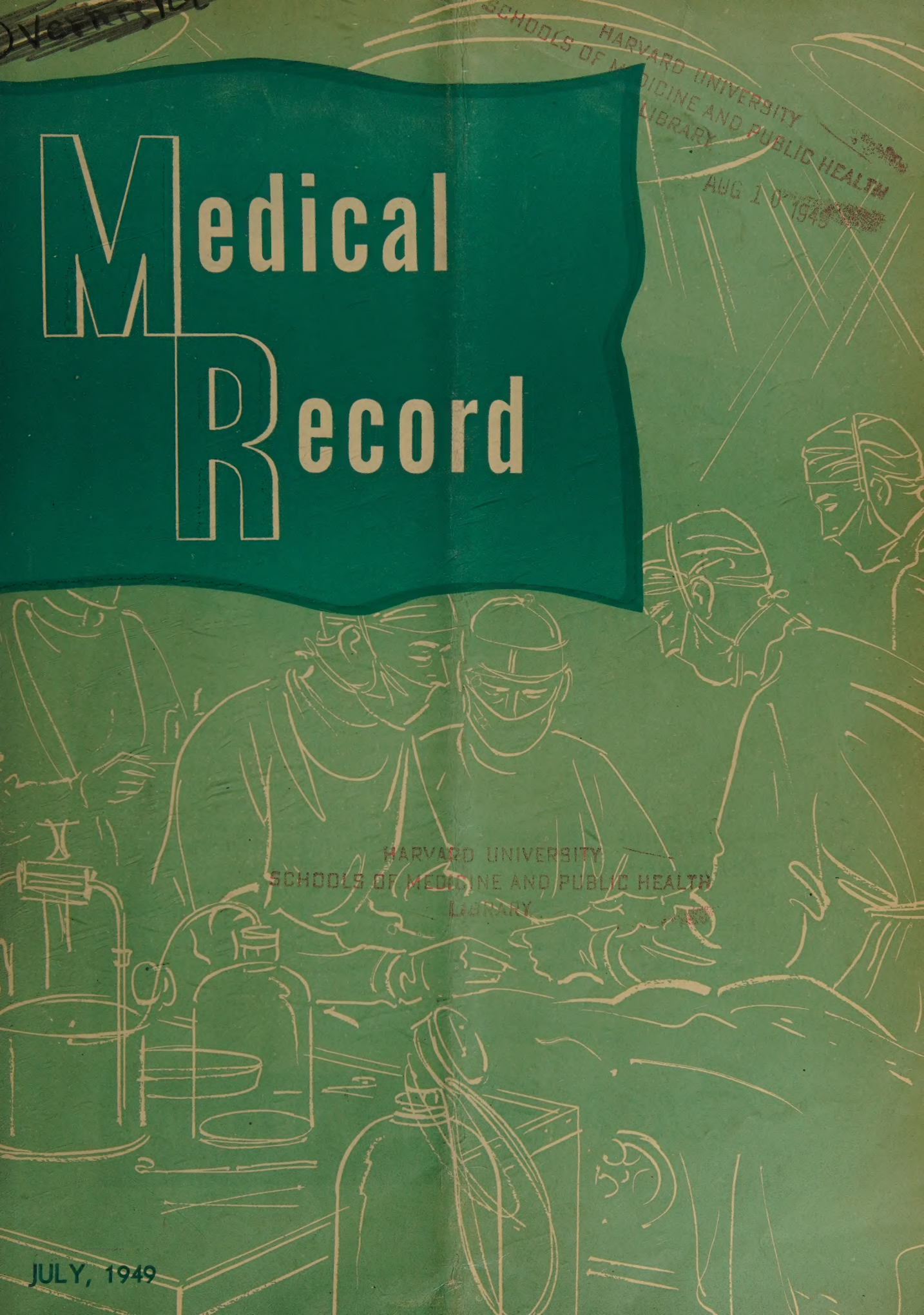

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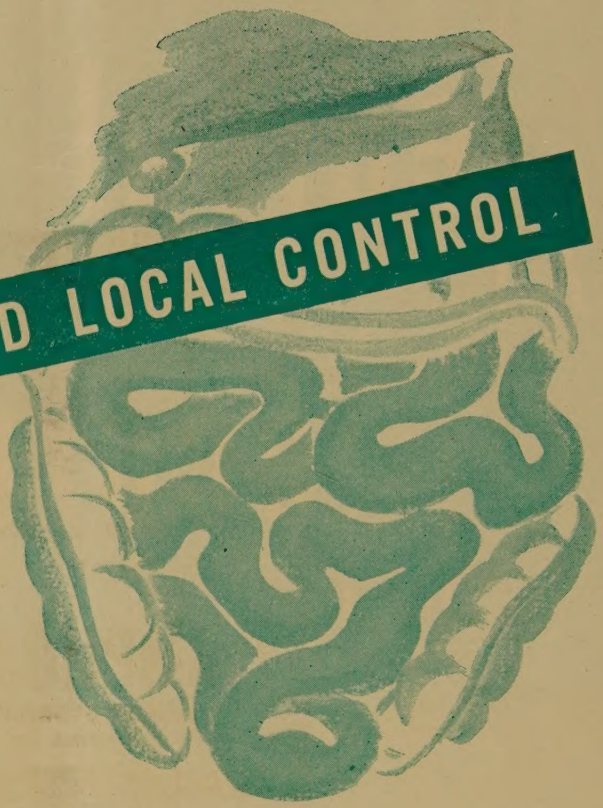

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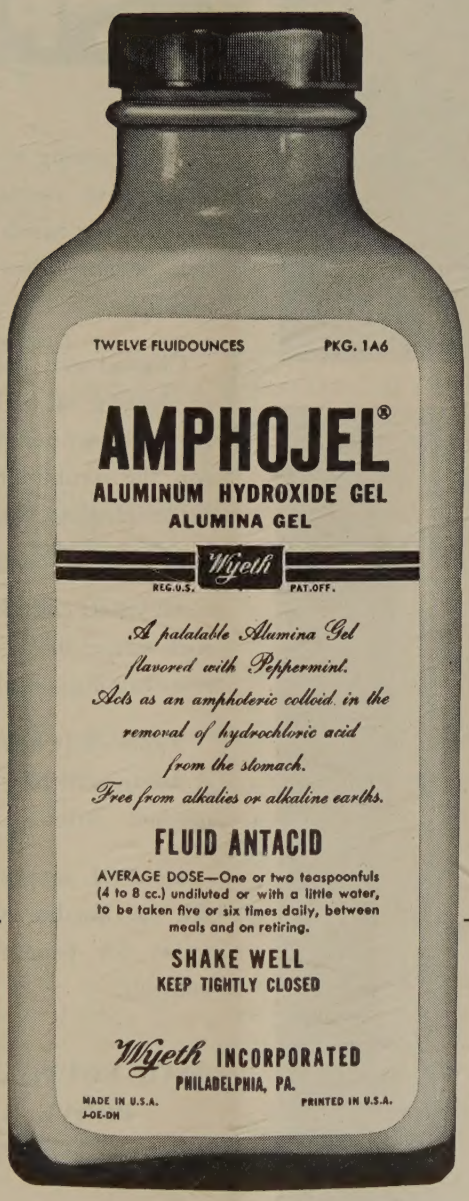
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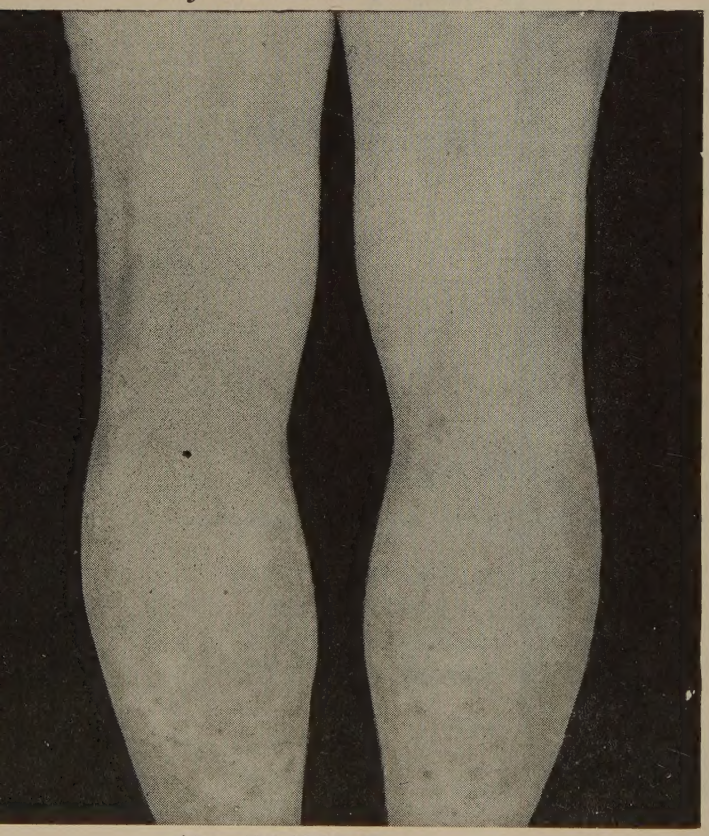

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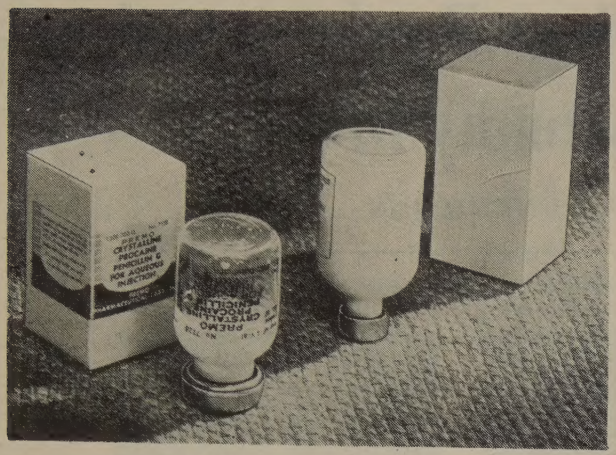

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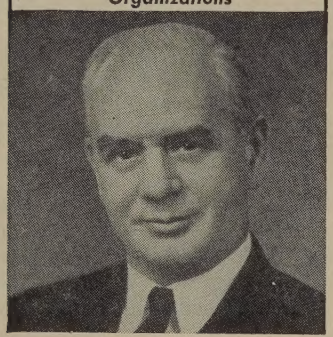

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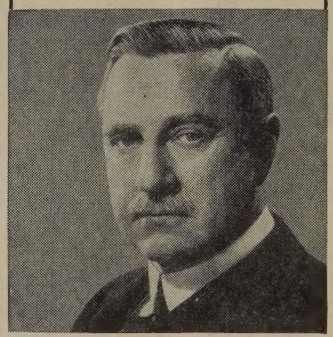

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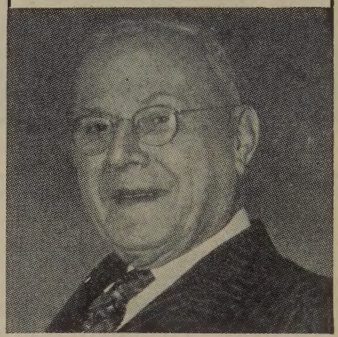

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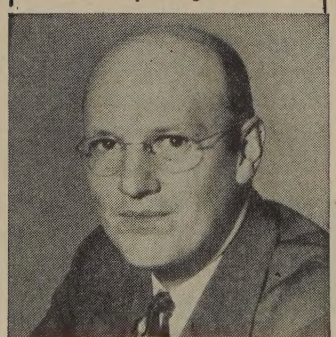

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CARDIAC RATE AND RHYTHM

J. ARTHUR BUCHANAN, M.D., F.A.C.P.
AND
JOSEPH C. INDELICATO, M.D., F.A.C.P.
Brooklyn, New York

Every doctor deals daily with problems associated with variations of the rate and rhythm of the heart. A clear understanding and interpretation of the meaning of cardiac rate and rhythm with their several possible normal and abnormal manifestations is a constant requirement.

The essential physiology of the cardiac muscle is contractility and conductivity. The heart muscle has the capacity of contracting and relaxing within a definite period of time. The rapidity of impulses produced by the contraction of the cardiac muscle determines the rate. The sounds produced by contraction of the muscle, and the opening and closure of the valves, determine the rhythm.

Cardiac rate means the number of cardiac cycles that are completed in a definite period of time. The rate may be determined by auscultating the heart, by palpating the pulse, or by various recording instruments. Heart rate may be normal, fast, slow, regular or irregular.

Heart rhythm can be determined only by the transmission of sounds produced by the heart. These sounds may be detected by ausculatation or recorded instrumentally. Rhythm as produced by the heart is the steady and persistent succession of beats or time units with periodic accents. Heart rhythms are classified or recognized by the presence of two or three sounds heard in succession in a given time interval with the accentuation of one of the sounds or tones.

Clinical practice traditionally determines the rate of the heart in all cases, but present knowledge makes the determination of the type of rhythm present equally burdened with significance. Heart rhythms have a terminology based on the accent sound or tone of each heart cycle as the cycle repeats itself in a period of time.

The study of the rhythm produced by the heart cannot be understood in all its manifestations unless correlated with the study of a discipline where rhythm is a distinctive characteristic. Music is this discipline. The recurring accented beat, or the omission of this beat at intervals, in a given measure of time, is the primary requisite for the creation of music, regardless of the source of the sounds produced. An analysis of certain scores of music will clarify the problem of understanding the rhythm of the heart, and will clearly separate the study of rate and rhythm. The number of tones, sounds or beats, in an interval of time constitute the rate in music as in heart contraction. The rhythm is often difficult to determine in highly technical music, as in heart examinations. The following bars (Figure 1) from the score of Bach's Preludio VII from the Well Tempered Clavichord, Book 1, illustrates the subject of consideration.
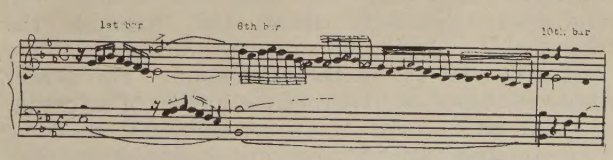
FIG. 1—The same rhythm is maintained in these bars, but the number of beats or tones varies in each measure

The rate of tone production if counted here is 16 in the first bar, and continues at that rate to the eighth bar where the rate is 32. In the tenth bar the rate drops to three. The rhythm is produced by accentuating, by slightly increased pleximeter blows, the first tone of each bar. The rhythm remains the same throughout this particular selection, whereas the rate varies greatly.

The normal heart produces two sounds which occur in succession, evenly spaced. These tones have been commonly likened to the tones of the syllables pronounced lub-dup. The first and longer sound is generally considered as being due to the contraction of the ventricular musculature and the closure of the auriculo-ventricular valves. In the instances in which only one tone is heard we call the phenomenon monatone heart action.

The second and shorter sound is possibly produced by the closure of the semi-lunar valves. The first of the two tones is the louder or accentuated one.

"Normal sinus rate" is universally recognized as a regular heart beating at the rate of 70 or 80 per minute. There is a true rhythm associated with this rate, but the same rhythm is heard in regular hearts beating at 120 to 160 times per minute. However, many textbooks presenting studies of heart disease include various changes in heart action; e. g., sinus tachycardia, regular paroxysmal tachycardia and auricular flutter with the arrhythmias. Analyzing these cardiac states in the light of the basic meaning of rhythm demonstrates that a rhythm is maintained in these forms of tachycardia, and that the inclusion of them with the arrythmias is erroneous.

Regardless of the rapidity of the heart action, if two sounds are produced in definite intervals of time one of which is accentuated, normal rhythm is maintained. Henceforth, these two words will be combined in eurhythmia to indicate physiologic heart rhythm.

Sinus rhythm as used in practically all cardiac textbooks today is erroneous. There are no tones produced in the sinus during its physiologic changes. Unimpeded transmission of stimuli resulting from sinus activity terminates in a type of rhythm, but the tones creating it are not dependent upon sinus action as the same tones are produced when a complete heart block exists. The term sinus rhythm as ordinarily used means rate of sinus activity and the term should be sinus rate.

SECTION I

Special Types of Heart Rhythms

The most important abnormal tones of the heart are those designated as gallop rhythm. Three distinct sounds are heard or recorded with each cardiac contraction. The triple sounds above 80, and more distinctly above 100, resemble the sound of a galloping horse with sufficient accuracy to justify the use of the expression. The slower rate with three similar tones is spoken of as canter rhythm on account of the resemblance to three tones produced by a type of slow equine locomotion. There are three types of gallop or canter rhythm depending on the position in the cardiac cycle of the third sound. They are classified with their characteristics in Table 1.

Table 1

Presystolic: In this type the third sound is heard before the first normal sound. The second sound is the accentuated and longer one.

Protodiastolic: In this type the third sound is heard just after the second normal sound. The accent is on the first tone. The third sound is the faintest. Protodiastolic type of gallop rhythm is by far the most common. It is often called "split second."

Systolic: In this type the third sound is heard between the first and second normal heart sounds, and is the shortest of the three beats. The accent is on the first tone.

Gallop Rhythm Tones

The keenly perceptive ear picks up the three tones that constitute gallop rhythm, but little attention has been placed on the quality of tones always included in gallop rhythm. There are times when this tonal quality is present when there are only two tones present, and rarely when one sound is produced. These tones defy description and are learned by clinical experience. Those instances where the tone qualities are present, but the number of tones less than three, we have designated as gallopoid tones with eurhythmia.

Bundle Branch Block

Bundle branch block is a condition in which an impulse may be conducted normally through the auricles, A-V node and the Bundle of His and then blocked in the right or left branch of this bundle. The presence of a block in either of the bundles prevents the normal synchronous contraction of both ventricles. The unstimulated ventricle depends for its stimulus on the transmission of the impulse from the normal ventricle. It is usually impossible to detect this condition clinically. It may be suspected, however, if a gallop rhythm or reduplicated heart sound is heard. It is of considerable importance, for it denotes some structural disease of the myocardium and often, but not always, denotes a grave prognosis.

This condition is made evident by means of an electrocardiographic tracing. There is no characteristic rate nor rhythm. Eurhythnia is present in the majority of cases.

Muscle and Nerve Relationship to Rate and Rhythm

A brief review of the physiology of the normal heart beat recalls that the normal impulse starts at the sino-auricular node which lies at the junction of the superior vena cava with the right auricle. The impulse travels rapidly over both auricles causing them to contract simultaneously, and continues to the ventricles through the junctional tissues (Figure 2). This conduction pathway between auricles and ventricles lies in the upper part of the inter-ventricular septum and consists of the auriculo-ventricular node or the Node of Tawara, and continues through the Bundle of His. This bundle divides into two branches, a

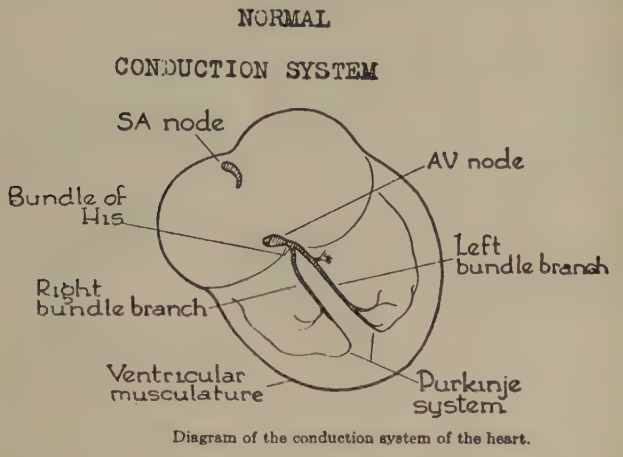

FIG. 2—The normal conduction pathways and the electrical response are outlined

right and a left, each going to the respective ventricle. The impulse finally spreads throughout the ventricular musculature by means of the elaborate network of the Purkinji system, which enables the ventricles to contract simultaneously. Normally the process repeats itself about seventy-two times each minute.

In general, it may be stated that the nerve supply of the heart comes from the sympathetic nervous system which supplies the heart generally and the parasympathetic vagus nervous system which supplies the SA and AV nodes. Stimulation of the former increases cardiac rate whereas stimulation of the latter slows the rate. Cardiac rate has a definite nervous system relationship.

SECTION II

HEART RATE

The following terms are used to designate the types of heart rates: 1. Normal Rate; 2. Bradycardia; and 3. Tachycardia. Any of the rates may be regular, or irregular, rhythmic or arrhythmic.

Normal Rate: This is the normal cardiac rate which occurs in the normal resting subject. Persons differ in their normal basal rate just as they do in the blood pressure, the metabolic rate, the color of the hair, and other bodily features. The normal rate, however, is usually 72 each minute. The term "normal rate" includes the rates between 60 and 80 each minute. The normal rate does not necessarily indicate a normal heart.

Bradycardia, Types: In this state the heart rate may be regular or irregular, and the action may accompany eurhythmia, gallop rhythm, monatone phenomenon, or arrhythmia.

Sinus Bradycardia: This term indicates a heart rate below 60 each minute. Slow rates are seen in myxedema, increased intracranial pressure, complete heart block, and in other states. The occurrence of this form of slow pulse is due to a regularly recurring long diastolic pause. A bradycardia of less than 50 per minute is distinguished clinically with marked difficulty from complete heart block.

Heart Block: Heart block is a disturbance in the cardiac mechanism due to a failure of an impulse leaving the sino-auricular (S-A) node to travel normally through the auricles to stimulate the junctional tissue.

The impulse may be delayed, gradually prolonged or completely obstructed thereby giving rise to a first, second, or third stage heart block.

In first stage heart block or delayed conduction time the impulse normally formed at the S-A node takes longer than the usual 0.14 to 0.20 second to reach the auriculo-ventricular (A-V) node. The heart rate is regular. The electrocardiogram shows that the time between auricular contraction and the beginning of the evidences of conduction activity is prolonged. The delay is the same with each cycle and each impulse formed reaches the A-V node in time to initiate a stimulus through the conduction system. There is no way that this type of heart block may be diagnosed clinically. A slow, regular heart should stimulate suspicion of a first stage heart block. Eurhythmia or gallop rhythm may be present in these cases.

Temporary Complete Heart Block or Second Stage Heart Block: This form of heart block gives rise to an irregular slow rate. In this form of disturbed cardiac mechanism the impulse normally initiated at the S-A node is progressively delayed so that there is a gradual prolongation of the P-R interval to a point where, periodically, a stimulus fails to reach the C-V node and a ventricular response is occasionally omitted from the cardiac cycle. This gives rise to a rare form of slow irregular rate. This condition is not difficult to recognize clinically as a complete pause in the heart sounds is detected. Usually the pause is detected every four, five or six normal beats. There may be periods of eurhythmia as well as periods of arrhythmia in these cases.

Complete Heart Block: When the impulses initiated at the S-A node fail to reach the junctional tissue a state of complete heart block is said to exist. The ventricles in this case set up an idioventricular rate which is regular. The S-A stimulus causes only the auricles to contract. The auricles and ventricles beat independently. The complete dissociation of auricles and ventricles is third stage heart block. The tones heard, although slow in rate, are eurhythmic with the accent on the first of the two tones produced by ventricular contraction and the closure of the valves. The eurhythmia is comparable to Lento or Largo in music, and, if extrasystoles occur, the rhythm is not changed. A gallop rhythm might be present.

Tachycardia, Types: In this state the heart rate may be regular or irregular and the action may accompany eurythmia, gallop rhythm, monatone phenomenon, or arrythmia.

Sinus Tachycardia: The heart rate may be rapid and perfectly regular with the beats following a normal course through the heart. When the rate is over 100, and regular, it is arbitrarily called sinus tachycardia. Some authors use this term when the heart rate is over 80 each minute. The natural response of the heart to effort and emotion is an increase in rate. Sinus tachycardia also occurs in fever, anemia, shock, hyperthyroidism, as well as in many other pathologic states. Sinus

tachycardia may occur in heart disease, but it is also seen in noncardiac conditions.

There are three other types of tachycardia which usually occur in paroxysms and must be distinguished from sinus tachycardia. The rhythm may be either eurhythmia or gallop and does not bear any relationship to the origin of the tachycardia.

Paroxysmal Auricular Tachycardia: In this type of tachycardia some ectopic focus in the auricle takes over the pace of the heart, sending out regular rapid beats that travel through the auricles in an abnormal route, and as normally through the junctional tissues to the ventricles. This condition may be more easily explained as rapid successive auricular premature contractions, starting abruptly, continuing for an indefinite period of time and ending suddenly, with or without treatment.

Nodal Tachycardia: The above mechanism is applicable when the site of origin of the ectopic beat is in the A-V node. However, the impulse, besides travelling down to stimulate the ventricles, may also travel upward to stimulate the auricles.

The clinical significance of auricular and nodal paroxysmal tachycardia is essentially the same as auricular and nodal premature beats. They do not indicate disease of the myocardium. If they persist at a rapid rate, however, congestive failure may result, but the myocardium returns to normal after the paroxysm ceases.

Ventricular Paroxysmal Tachycardia: This form of tachycardia is produced by an ectopic focus in the ventricles initiating impulses at a rapid and regular rate. It is usually more serious than the auricular or nodal forms as it indicates strongly the presence of cardiac disease in patients in whom it is not precipitated by the administration of digitalis, quinidine or other types of drugs. Sometimes ventricular fibrillation follows this type of tachycardia and may be a terminal event. It may occur after coronary occlusion or other severe forms of organic heart disease.

Auricular Flutter: This is a comparatively rare type of tachycardia in which the auricles are beating from 250 to 350 per minute. Auricular flutter is due to a circus movement formed about the auricles which conducts impulses so rapidly to the ventricles that the latter are very rarely able to respond to all of them. The ventricles in this form of tachycardia respond to every second, third, or fourth auricular impulse giving rise to a 2–1, 3–1, or 4–1 ventricular heart block rate. Hence, if the auricles are beating 350 each minute, the ventricular rate may be 175, 117, or 88 each minute, but regular. The rhythm is normal in most instances, but disturbances may occur momentarily if the rate of ventricular response varies.

SECTION III

Irregular Rates

There are five types of irregular rates. Some irregular rates are not associated with arrhythmia. 1. Sinus Arrhythmia; 2. Auricular Fibrillation; 3. Ventricular Fibrillation; 4. Premature Beats or Extra Systoles; 5. Sinus Arrest.

Sinus Arrhythmia: Sinus arrhythmia is an irregular rate characterized by varying lengths of time between cardiac cycles. This is the most common type of cardiac arrhythmia. The rate is irregular. The change of rate usually varies with respiration, the periods of shortened lengths, therefore, more beats, occurring during inspiration, and the periods of greater lengths with the slower rate during expiration. The changes in the length of the heart cycle are gradual and take place almost always at the expense of the length of the diastolic pause. The length of the systole remains unchanged except in rare instances. This type of arrhythmia and irregular rate is very often found in children and elderly individuals with otherwise normal hearts. The variation in the distance between beats is the physical criterion for recognition, but its presence alone is no indication of heart disease.

Auricular Fibrillation: Auricular fibrillation is an abnormal cardiac rate produced by the rapid fibrillary state of the auricular musculature. The number of fibrillation contractions vary from 400 to 800 each minute. It resembles auricular flutter in that it results from a circus movement in the auricles, but the rate of circus is more rapid, and the pathway is irregular. The auricles do not contract co-ordinately and remain distended. The conduction system of the heart carries a greater number of impulses from the auricles to the ventricles, but the rate of the heart may be 100 or 150 or more. Occasionally with treatment the rate may be slow or below normal, simulating some form of heart block.

Auricular fibrillation is the most common important irregularity of the heart. Once found, this type of irregularity may remain the permanent mechanism of conduction or it may occur in paroxysms lasting only a few minutes, hours, or days, and may be terminated by medication or change to eurhythmia spontaneously.

Ventricular Fibrillation: Ventricular fibrillation is a condition found usually as a terminal event in which the ventricular musculature of the heart falls into a fibrillatory state. The ventricles cease to contract and unless the mechanism rights itself within a few minutes, death ensues. Rate and rhythm cannot be ascertained during this mechanism.

It is probably the cause of sudden death in many individuals following coronary occlusion.

Premature Beats or Extra Systoles: A premature beat is a beat which occurs unexpectedly at some phase in the basic rhythm of the heart. Depending on the site of origin, premature beats are classified as auricular, nodal, or ventricular. Premature beats are followed in most instances by a compensatory pause which accounts for the long interval noticed following their occurrence. Regardless of their origin they have a tendency to alter cardiac rate, but the basic rhythm is maintained. Their presence, especially when frequent, is distinguished with difficulty from auricular fibrillation.

When the heart rate is sufficiently slow, or the premature beat comes so early in the cycle that the sequential auricular impulse finds the ventricle out of its refractory state, the premature beat is "interpolated" between two normal beats without a pause, and therefore, the three consecutively

quick beats may be heard. The interpolated beat is a true extra-systole.

Premature beats are very commonly encountered in the examination of patients with and without organic heart disease. They must not be regarded *ipso facto* as evidence of heart disease. They are found in healthy individuals. They may occur in the slow or fast heart, and in the presence of eurhythmia, as well as in the various types of arrhythmias. Occasionally, the occurrence of premature beats is brought on by the overdose of digitalis. They may be the first sign that digitalization has been reached.

The succession of rapidly produced notes is comparable to runs of grace notes in music and in such cases the rhythm of the heart is maintained. These runs of extrasystoles are clearly understood by comparing the sequence of events in Mendelssohn's Spring Song. The first four bars clearly illustrate the relationships of extra beats to the dominant rhythm (Figure 3).

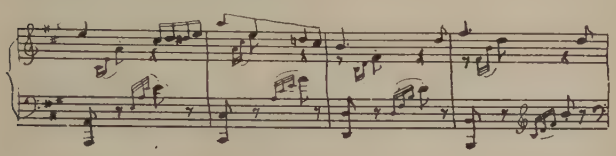

FIG. 3—The small notes joined by bars are the grace notes. They are thrown in and do not disturb the rhythm, but they do change the rate of tone production

The extrasystoles may be viewed as embellishments of the heart rhythm as in music. The example from the Spring Song is impressive, but there are no records of states where three extrasystoles proceed or follow physiologic heart contractions. Runs of extrasystoles are seen in cases of auricular fibrillation. The occurrence of one or two extrasystoles is common in pulsus bigeminus or trigeminus.

These states are illustrated in Lebert and Stark's studies of musical embellishments (Figures 4 and 5).
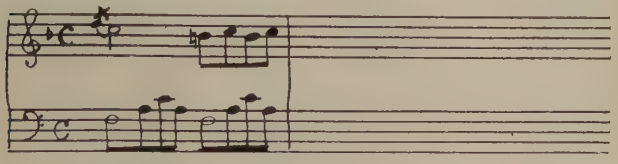
FIG. 4—Illustrates a single grace note or extrasystole occurring before the first note of the bar

Extrasystoles are embellishments to the rhythm present, or lack of rhythm. They are to the cardiac cycle as grace notes to the musical cycle.

Extrasystoles demand that the cardiac examiner determine definitely the significance of rate and rhythm. The counting of the heart beat will show an irregular rate, but listening to the heart sounds will determine the existence of a basic rhythm, although sounds may occur during the interval of listening that seem to disturb this rhythm. The bars of music from Bach's Preludio VII (Figure 1) as mentioned, demonstrate the significance of this statement.

If these notes could be palpated with the fingers a great irregularity of impulse production would be experienced. The rate would be entirely irregular. The auditory reception would be distinctive if the rhythm were produced in accordance with the requirements of the musical discipline. The accentuated notes would be brought out in their proper place or be omitted to occur again in a given interval of time. Many additional beats or tones make rate, but do not alter the rhythm. If one counts rate in the electrocardiogram the rhythm can only be experienced or imagined psychologically.

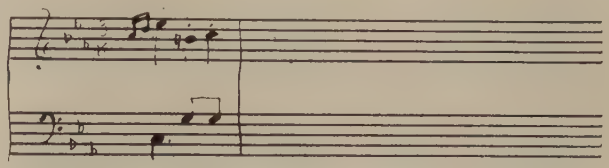

FIG. 5—Illustrates two grace notes or extrasystoles occurring before the first note

Sinus Arrest: Sinus arrest is a rare form of cardiac irregularity in which the heart beat stops for a brief interval. In this condition there is complete asystole for a varying period of time because there is an actual failure of both auricles and ventricles to contract because of the absent stimulus. Sinus arrest usually results from overstimulation of the vagus nerve. Sensitivity of the carotid sinus is one of the mechanisms responsible. It is not necessarily associated with heart disease, as attacks are often precipitated by prolonged standing, a sudden twist of the head, an overheated or overcrowded room, the sight of blood, the prick of a needle, or other sudden emotional upsets. On auscultation one hears a marked slowing of the heart or a sudden pause, generally accompanied by a fall in blood pressure.

SECTION IV

THE ARRHYTHMIAS

All types of arrhythmias show an irregular rate of the heart, and in consequence an irregular pulse.

Sinus Arrhythmia: This is the most common type of arrhythmia of the heart. The essential characteristic is the variation in the length of the diastolic portion of the heart cycle (Figure 6). This variation results from vagal action on the sino-auricular node in such a way as to retard or stimulate its activity.

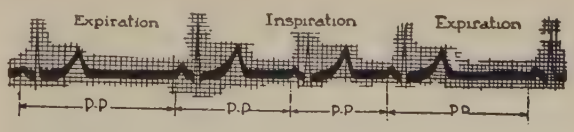

FIG. 6—The loss of rhythm is due to the long diastolic period which throws the accented beat out of correct time interval

This type of arrhythmia if marked may be recognized clinically by pulse palpation or cardiac auscultation. Electrocardiograms show a variety of waves, but the type in each case is constant, except in rare instances where there is an abnormality in the P wave at the onset of the arrhythmic period.

Sino-Auricular Block: In this type of arrhythmia a complete heart cycle is omitted from a series of regularly and rhythmically occurring cycles. The interval of no cycles is about double the normal time interval, but in some instances the interval between cycles may be three or four times the normal.

Ventricular Escape: This type of arrhythmia occurs in slow hearts, when the interval of no auricular activity is markedly delayed. The ventricles contract independently.

Auricular Standstill: Although this rare phenomenon has been called an arrhythmia, there is a true rhythm present and the rate is regular.

The usual number of cardiac tones are produced at each cardiac contraction, unless gallop rhythm is present. This type of standstill is only recognized electrocardiographically.

Parasystolic Rhythm: This unusual type of rhythm occurs when the sinus node and A-V node have their own independent rhythm competing for control of the heart cycle. This phenomenon is also called interference dissociation, as in those instances where the A-V node controls the heart rhythm, the sinus node may produce an occasional ventricular beat. In such instances the auricles are protected from stimuli from the A-V node as they are in a refractory state, and at the same time the refractory state does not exist in the ventricle, hence its contraction. The associated rhythm may be faster or slower than the dominant rhythm. The occurrence of two rhythms produces the impression of arrhythmia, but in truth the state is one of confusion created by two rhythms occurring as nearly simultaneously as possible in the heart.

Sinus Arrest: Sinus arrest must be distinguished from Sino Auricular block. Sinus arrest is due to absence of impulse formation, and the latter to blockage of the impulse emitted by the sinus node. Sinus arrest is diagnosed by the electrocardiogram which shows a pause or a series of pauses of approximately two, less often three or four, times the normal P-R interval. During these periods a type of arrhythmia is produced, while in the intervals eurhythmia prevails. The significance of the long rest periods cannot be determined easily except by electrocardiography, although additional diagnostic criteria may be obtained by observing the jugular pulse.

Auricular Fibrillation: The complete absence of uniformity of timing and force makes this type of arrhythmia easily determined. There are instances when the slow heart action causes difficulty in recognizing the condition. The tracing in Figure 7 shows eurhythemia at periods of time in spite of the absence of P waves, and there were periods of complete arrhythmia at various times in the same patient.

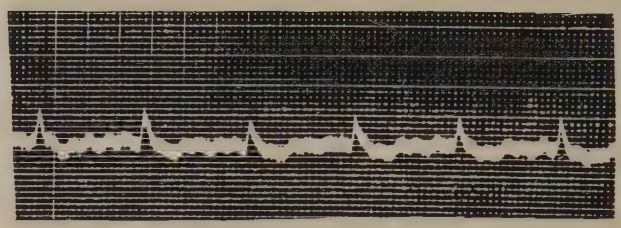

FIG. 7—This electrocardiogram demonstrates eurythmia occurring in case of auricular fibrillation. The usual two heart tones were audible. Slow auricular fibrillation may be unrecognized clinically without an electrocardiogram.

Paroxysmal Auricular Tachycardia: There is eurhythmia in these cases as a rule. During the transition period either of access or regression there may be a period of arrhythmia characterized by varying lengths of the diastolic period. The arrhythmia during these intervals is the same as in sinus arrhythmia (Figure 6).

Auricular Flutter with Irregular Conduction Ratios: In instances where the ratio of auricular contractions to ventricular contractions varies a type of irregular and arrhythmic heart action occurs. This type can be determined by electrocardiographic studies. The dominant rhythm of the heart is disturbed and there are no clinical criteria for its recognition by physical examination.

Chaotic Heart Action: This term indicates the occurrence of frequent premature systoles of multiple points of origin, occurring singly or in short paroxysms and especially when ectopic foci are not confined in the ventricles or auricles alone but come from both chambers, or in addition from the A-V node. There is, of course, complete arrhythmia as the dominant rhythm is utterly disarranged.

Temporary Complete Heart Block: In these instances the arrhythmia is difficult to determine clinically. The period of absent beats occurs so irregularly in some instances that the arrhythmia is confused with auricular fibrillation. The electrocardiogram clarifies the situation.

Ventricular Fibrillation: This is a condition found usually as a terminal event in which the ventricular musculature of the heart falls into a fibrillatory state. There is total lack of rhythm, and the rate is irregular. The ventricles cease to contract and unless the mechanism rights itself within a few minutes, death ensues.

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ORAL FOCAL INFECTION AS CAUSE FOR DISEASES OF THE ORGANS OF THE UPPER ABDOMEN, ESPECIALLY THE LIVER

The Diagnostic Importance of the Blood Count

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The J.A.M.A., commenting on focal infection (1) and in this connection especially referring to a presidential address to the Institute of Chicago by Ernest E. Irons, stated in January 1947, "Today the concept of focal infection has been integrated into the practice of medicine. One speaks no longer of the theory of focal infection, one recognizes focal infection as a definite pathologic condition requiring scientific diagnosis and treatment."

It is a well established fact that a focus of infection in the teeth or tonsils will eventually affect any distant organ such as the heart, kidneys or joints and according to results of bacteriologic investigations it is streptococci, staphylococci and diphtheroids being mostly responsible for these complications. In this connection, Appleton's book *Bacterial Infection* (2) must be mentioned for detailed information.

It was already previously reported (3) that since the end of World War I an increase in gastrointestinal diseases has taken place and it was pointed out that most of these cases concern the large glands of the upper abdomen, esp. the liver. In that paper, it was stated that the hepatoendothelial system (HNS) directs the leukocytes and it was asserted that lymphocytosis means diseased HNS and impairment of the liver, its chief organ. The frequent finding of lymphocytosis thus acquires specific importance and for its cause all diseases have to be taken into consideration that through the HNS provoke acute liver cell damage or after subsidence of this stage, leave this organ with chronic dysfunction. Only too often the past history does not point to the true cause, and it is here that the blood count is to serve as diagnostic guide.

In many examined cases the blood picture did not only show lymphocytosis but also anemia, a shift to the left and monocytosis. Therefore, a chronic focus of infection was suspected and accordingly the teeth and tonsils were examined in reference to this condition. These examinations revealed that most patients often even those of juvenile age had large fillings in their teeth and rather frequently some of them were dead, covered with gold crowns. Finally, the teeth were systematically X-rayed and the results were most surprising. In most cases there were found dental foci of infection in form of alveolar pyorrhea, abcesses and osteomyelitic changes of the jaw bones, and the damage they can produce in the large glands of the upper abdomen is reported in the following rare case:

D.F. Male. Age: 48 years. As child only measles. Asserts to have been always healthy. Lived in tropics for five years before World War I. No tropical or venereal diseases. Married, one healthy child. Patient started to feel bad in April 1931. Short attacks of fever—considered as grippe by him—cleared up within 1–2 days. On 8/7/31, again attack of fever.

Findings: Rather tall, sufficiently developed, pale looking man. Visible mucous membranes pale. No own teeth in upper jaw. Teeth in lower jaw just very slightly loose, but no pyorrhea. Heart: outlines normal. First at apex accentuated, pulse 110, regular, small. BP. 112/84. Abdomen: distended. Liver: enlarged by one finger, tender to touch. Spleen: enlarged, tender. Knee jerks: ++. Temperature: 100.7.

On 8/10/31, patient felt better, the temperature having come down to normal. He was not seen until 10/2/31 when he asked for an examination again. Findings were as follows:

General condition much worse, patient looking seriously ill. Inappetence. Constipation. Can barely walk. Unable to work. Sclerae: greenish tinge. Liver: enlarged to navel, extremely hurting to slightest touch. Spleen: very much enlarged, tender to touch. WaR: negative. Suspicion of a tumor of the gastrointestinal tract was not confirmed by X-ray examination.

Already in August 1931, the patient had been advised that a blood count was needed for proper diagnosis but by that time he did not consider himself so sick as to require this test. Finally, he agreed to have it done and the report helped to solve his case.

The blood count (see table) showed a rather severe hypochromic anemia with slight leukocytosis, lymphopenia, a shift to the left and monocytosis. These last two facts made a focus of infection probable, the teeth were examined again and to slightly stronger pressure thick pus appeared be-

tween the gum and the teeth of the lower jaw. Finally, the patient could be persuaded to have all these teeth extracted in spite of his obstinate objection of having never had the slightest inconvenience from them. (The attending dentist declared to have never seen any case like this one). From the day of the removal of the teeth, patient improved rapidly.

On 10/17/31, patient was started on injections of liver extract and As by mouth. The improvement of the blood count is reported in the table. The size of the liver and spleen decreased according to the recovery of the blood. On 6/29/32, liver and spleen were practically normal in size, patient was in excellent general condition and continued to feel good as confirmed by another blood count in November 1932.

This case, uncommon in its extreme degree, is especially instructive from the diagnostic point of view. Without a blood count the true cause of disease would barely have been recognized. During this severe illness which at first took unnoticed place in the lower jaw it was not the teeth but the large glands of the upper abdomen—liver and spleen—which formed the center of diagnostic deliberations. The connection between focal infection and disease of the upper abdomen seems to be definitely proved because improvement in the condition of the patient only started after extraction of the teeth cleared the severe infection up. Simultaneously the detoxifying role the liver is playing in the human body is again demonstrated. The toxins absorbed from the site of the focal infection enter the circulation and are finally carried through the Art. hepatica to the liver and it is its endothelial part which in connection with the spleen has to dispose of them. In the above reported case the course of disease was such that the toxins formed around the only slightly loose teeth did scarcely enter the oral cavity but were pressed into the capillaries. Being an extensive infection already lasting for months, liver and spleen were barely able to handle the steady task of detoxication: the lymphopenia of the blood count proved the seriousness of the situation and if the patient would not have finally submitted to proper treatment prognosis in this case would not have been doubtful.

The purulent process around the teeth must have suddenly changed without recognizable cause from a chronic to a subacute condition. On August 10, 1931, the blood count showed besides lymphopenia, 12.8 per cent monocytes, 8.6 per cent polymorphonuclears, 56.4 per cent segmented neutrophiles, thus a shift to the left of 1:7. These figures are important; they will be discussed later on.

Another case, by far not as severe as the preceding one, offers similar findings:

E.P. Male. Age: 38 years. As child measles and frequent sore throats. Later, always healthy. For some years "nervous stomach" and constipation. Cannot eat fried or fat foods. After meals often eructations, pain in pit of stomach. *Findings:* Rather tall, sufficiently developed, pale-yellowish looking man. Throat: red (smoker). Teeth in bad shape, some loose. Heart: outlines and sounds normal. BP. 105/74. Lungs: over both sides scattered moist rales. Abdomen: slightly distended. Liver: enlarged by one finger, hurting to touch. Spleen: enlarged, tender. Urine: Urobilinogen increased. Gastric analysis: Gastric juice, reaction sour. Free HCL: 33 per cent, combined acidity: 54 per cent. Van den Bergh: direct neg., indirect: 0.34mg per cent.

The blood count (see table) offered 37 per cent segemented neutrophiles, 45 per cent lymphocytes, 13 per cent polymorphonuclears, 5 per cent monocytes, thus a shift to the left of 1:3. X-ray examination of the gall bladder was negative. But X-ray examination of the teeth revealed extensive alveolar pyorrhea and four abscesses. Patient was advised to submit to dental treatment. This patient too did not like the idea of having his teeth extracted but finally had them attended to. After some months his gastrointestinal condition improved. A check-up revealed a decrease in the size of the liver. Patient did no more complaining of his stomach; the bowel movement was regular.

A brief report on a third case follows:

C.H. Female. Age: 50 years. Complained of eructations and nauseousness, pain in pit of stomach after meals and constipation. Liver and spleen were enlarged and tender to touch. The blood count (see table) showed 48 per cent lymphocytes, aneosinophilia, 1.6 per cent polymorphonuclears and 8.8 per cent monocytes. The X-ray examination of the teeth revealed extensive alveolar pyorrhea. Patient was referred for dental treatment and improved satisfactorily.

In a fourth case:

H.N. Female. Age: 28 years. Patient offered the same gastrointestinal complaints. The liver was not enlarged but its edge tender to touch and the spleen was normal. The blood count offered a slight anemic condition, 46 per cent

TABLE OF BLOOD COUNTS

Case	Date	Erythr. In Mill.	Hemogl.	Leukoc.	Bas.	Eos.	Juv.	Neutroph. Polym.	Neutroph. Segm.	Lymph.	Mono.
1. F.D.	10/8	3.7	66%	10.500	0	1.0	0.4	8.6	56.4	20.8	12.8
	11/19	3.85	75%	8.100	0.4	22.0	0.2	4.4	38.4	29.6	5.0
	6/29	4.96	99%	7.200	0	2.0	0	1.0	65.0	31.0	1.0
	11/10	4.8	96%	7.300	1.0	2.8	0	5.6	53.2	32.6	4.8
					Remarks: 11/10, 32: Ac. rhinitis.						
2. E.P.	9/4	5.03	105%	9.150	0	0	0	13.0	37.0	45.0	5.0
3. C.H.	11/1	4.2	77%	4.300	0	0	0.2	1.6	41.4	48.0	8.8
4. H.N.	10/10	4.0	71%	4.900	0	5.2	0	0.6	39.4	46.0	8.8

lymphocytes, 8.8 per cent monocytes, 0.6 per cent polymorphonuclears. X-ray pictures of the teeth revealed two large granulomas.

It is deemed unnecessary to continue the report on more cases; the list could be extended indefinitely. It always is the same situation that prevails. The patient wants to be treated for his "nervous stomach" or general complaints such as listlessness and tiredness. Systemically seen, the stomach will rarely be affected independently, only too often it covers up dysfunction of the large glands of the upper abdomen, esp. the liver. This organ is found to be much more frequently diseased than is usually recognized and then it is necessary to look for the true "causa". The blood count is indispensable for this purpose. In most cases it will show lymphocytosis pointing to the liver. If the differential count offers monocytosis, a chronic focus of infection must be considered. In case inflammatory processes such as small furuncles can be excluded diagnostic deliberations must center around the teeth. An oral cavity with large fillings or dead teeth calls for thorough X-ray examination of all of them. Only too often focal infection is found and then the question of dental treatment arises. For decision on this important point valuable help is supplied by the blood count.

Provided that changes in the differential count are exclusively caused by the teeth monocytosis will mean chronic focal infection and conservative treatment can be advised. (Case 3+4).

Monocytosis and a shift to the left of the neutrophiles will concern a subacute or acute process and active therapy will have to be recommended. (Case 1+2).

If focal infection is diagnosed and the differential count is found to be normal, an inactive focus must be supposed and immediate treatment is not deemed necessary.

However, in cases of alveolar pyorrhea with loose teeth extraction is the only therapy possible.

If the oral cavity is thoroughly inspected focal infection not only of the teeth but also of the tonsils will frequently be discovered. Very often it is chronic tonsillitis with many tonsilloliths found in the crypts. Observations over years have shown that after proper treatment of infected teeth the condition of the tonsils improves, a fact also noted by Otto Meyer (4). The question arises though what will be the fate of those patients whose tonsils have been removed when they were young and their teeth should develop focal infections in later life. It seems that in such cases the lymphoid tissue of the tongue is taking over for the tonsils and another focus of infection is formed there. In one case of rheumatoid arthritis auto-vaccine made from a smear of the tongue containing staphylococcus aureus helped the patient more than any other kind of treatment.

It is the gastrointestinal tract that is usually first affected if focal infection prevails for some length of time. Its after-effects must not always be neuritis, nephritis or arthritis. The detoxication of the toxins produced in the focus is always performed by the HNS, especially liver and spleen. Thus, the fact is explained why in so many cases the past history does tell of gastrointestinal disorders. It is here where the blood count with its diagnostic importance comes in. It will unveil the connection between focal infection and gastrointestinal disease. Diagnosis will be secured, necessary therapy will be made possible and only after proper eradication of the focus of infection arises the probability that the diseased organs of the upper abdomen will improve again. Thus, the requirement to apply causal and not symptomatic therapy is fully complied with.

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33 Barclay Street

IMPREGNATED SALT TABLETS

The Naval Research Institute at the National Naval Air Center, Bethesda, Maryland, has developed a new slow-dissolving salt tablet which releases some salt immediately after taking, but causes no stomach distress or nausea. Product is being manufactured by the United States Safety Service Company, Kansas City, Missouri.

Pep-Up Impregnated Salt Tablets will withstand high temperatures and humidity of tropical climates as well as the friction and impacts of handling and will not absorb moisture from the air and clog dispensers.

Package for the product is a dispenser which is a sturdy container having a built-in dispensing unit. Container can be attached to wall. Factory sealing insures sanitation.

VERSATILE ANTIBIOTIC

For use in the treatment of oral bacterial infections, Aureomycin Troches are newest form of versatile antibiotic to be marketed by Lederle Laboratories Division, American Cyanamid Company, Pearl River, New York.

Aureomycin Troches are designed to be dissolved in the mouth and to exert their action upon the mucous membrane of the mouth, oropharynx and upper respiratory tract. They are useful in mild infections caused by Gram-positive, Gram-negative and other mixed bacterial organisms. Infections caused by streptococci, staphylococci, and pneumococci are the commonest of those affected by aureomycin.

In severe mouth and throat infections, the troches should be used in addition to therapeutic administration of aureomycin by means of tablets.

CARDIAC ARREST IN UREMIA ASSOCIATED WITH POTASSIUM INTOXICATION

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The lethal effect of high blood serum potassium values was suspected as early as 1839, when Blake (1) suggested that death which followed the intravenous injection of potassium salts into animals was due to the sudden cessation of the movement of the heart. Only recently has sufficient experimental and clinical data been accumulated to show the importance of potassium in the physiology of the heart muscle. The characteristic electrocardiographic pattern associated with a marked increase of potassium concentration of the serum has been rarely noticed in uremia. These changes were observed in a patient with uremia secondary to amyloidosis of the kidney and to an acute exacerbation of a chronic pyelonephritis. The case presented gives a clear demonstration of the electrocardiographic pattern which is consistent with those attributed to potassium toxicity in both experimental animals and the few human cases reported. The occurrence of potassium accumulation in the blood in renal failure is exceedingly rare; but since potassium balance can only be maintained by continued excretion in the urine, it is not surprising that there should be a rise of serum potassium in kidney failure. These effects have occurred spontaneously in uremia (2, 3, 4, 5) and also as a complication following the administration of potassium salts as a diuretic (5).

Case Report

A 60-year-old white female was admitted to the Jewish Hospital of Brooklyn with the chief complaints of weakness, nausea and vomiting for the past two months. Her past history showed the usual childhood diseases; arthritis involving all the small joints for the past 30 years; hypertension up to 220 systolic for the past three years; and angina and dyspnea of effort over this three year period. No unusual medication, such as digitalis, quinidine or potassium salts, had been taken.

The patient had been weak and ill for the three months previous to admission, with alternating periods of diarrhea and constipation. There was also fatigue, anorexia, weakness, nausea and vomiting. She vomited several times a day and the vomitus was green in color; it did not contain undigested food. Stools were small and black for the past week but the patient was taking liver and iron during that time. The patient complained of generalized abdominal and back pain. The urinary history was negative.

Physical examination on admission showed a drowsy, well nourished and well developed 60-year-old white female. She was lethargic and frequently dropped off to sleep. Temperature was 98.6° F.; respirations 22 per minute. The pupils were equal and reacted to light and accommodation. Retinal examination showed arteriovenous nicking; sclerosis of the vessels, and normal discs. A whitish plaque was present on the posterior pharyngeal wall. The lungs were clear to percussion and auscultation. The heart appeared enlarged to the left by percussion. The second aortic sound was snappy in character and greater than the pulmonic sound. A systolic murmur was present over the apex and over the aortic area. The rhythm was regular with a rate of 84 per minute. The blood pressure was 90/50 in the left arm; unobtainable in the right arm. Heart sounds were of poor quality. Abdominal, vaginal and rectal examinations were negative. There was a brownish scaly lesion over the anterior aspects of both lower legs associated with varicosities, but no edema. The small joints of the hands and feet were markedly deformed. All the reflexes were active. No abnormal reflexes were obtained.

Course in Hospital

A diagnosis of uremia was entertained and appropriate blood studies were done. The CO_2 combining power was 15 vol. per cent with a blood urea of 148 mgm. per cent. The urine showed 3+ albumen. An electrocardiogram showed a heart rate of 63 per minute with absent P waves, elevated ST segments in Leads 1 and 2 and abnormally large T waves (Fig. 1-A). Because of the acidosis the patient was given 2000 c.c. of 1/6 molar sodium lactate by hypodermoclysis. In view of the shock-like state and abnormal electrocardiographic findings, a diagnosis of potassium intoxication was considered and the patient was treated with adrenal cortical extract (30 c.c. over a period of 16 hours), intravenous calcium gluconate and glucose in saline administered intravenously.

Four hours after admission the patient went into peripheral shock. The blood pressure could not be

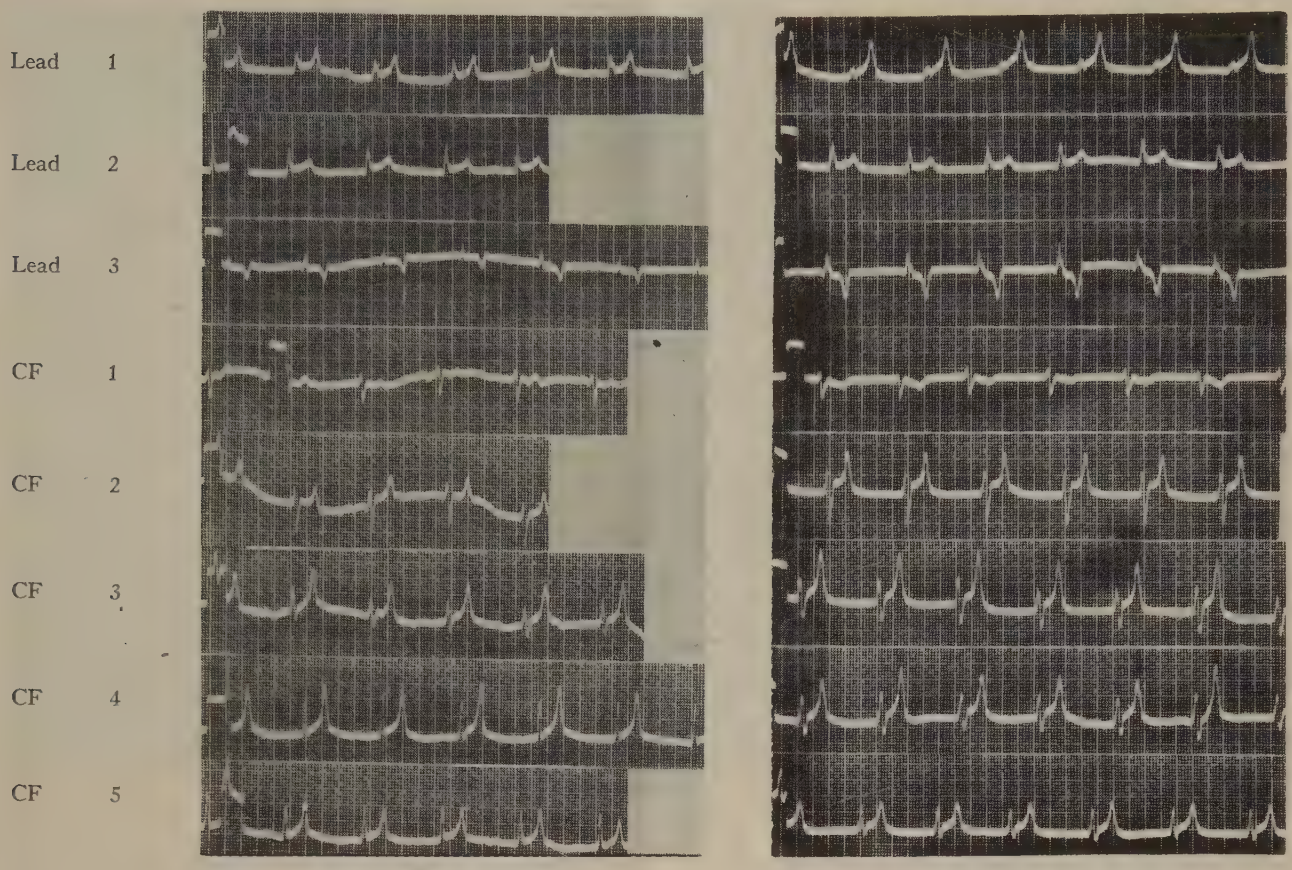

FIG. 1—A. Tracing taken on admission. Rate: 63 per minute. Absent P waves. Intraventricular conduction defect. QRS: 0.12 seconds. Elevated ST segment. High T waves. B. Four hours later. No medication administered. Rate: 63 per minute. Occasional premature nodal contractions. P waves absent. Intraventricular conduction defect. QRS: 0.12 seconds. ST segment elevated. Further elevation of T waves

determined. Heart sounds were muffled and prolonged and a definite cardiac rhythm could not be determined. The electrocardiogram (Fig. 1-B) showed a further spread of the QRS complex, auricular standstill and further elevation of the ST segment and T waves. Following injections of both calcium gluconate and adrenal cortical extract the patient improved. There was no evidence of shock; the pulse was stronger and now regular. Four hours after this attack the patient was conscious and responded to questioning. At this time the electrocardiogram showed very little change (Fig. 2). Despite this treatment the urea remained at 144 mgm. per cent, creatinine 10.9 mgm. per cent and uric acid 9.2 mgm. per cent. The CO_2 combining power however rose first to 48.4 vol. per cent then to 72.4 vol. per cent, two days after admission. Lactate solution was then stopped. The patient passed very little urine during her hospital stay and catheterization only obtained small amounts of urine (Table I). Twelve hours after admission the electrocardiogram showed a normal sinus rhythm (Fig. 3-A). On the third hospital day the pulse became irregular; the blood pressure was 126/76. Digifolin, 2 c.c. intramuscularly, was given at four-hour intervals. She exhibited periods of frequent twitching which subsequently turned to convulsive seizures. Following a convulsion, she went into coma and continued thus until exitus on her fourth hospital day.

NECROPSY

There was slight pitting edema of the legs. The peritoneal cavity contained 100 c.c. of cloudy yellow fluid and the peritoneal surfaces were smooth and glistening. The liver edge was 2.5 cm. below the right costal margin. The pleural cavities contained no free fluid. There were a few fibrinous and fibrous adhesions over the lateral surface of the right lung and there were fibrinous and fibrous adhesions over the entire left lung, especially heavy on the diaphragmatic surface. The pericardial sac contained about 75 c.c. of cloudy yellow fluid with a fibrinous exudate on the inner surface of the parietal pericardium. Almost all the organs and tissues in the body were edematous.

The heart weighed 330 grams and measured 11.0 cm. from apex to base and 10.5 cm. across the base. The apex was rounded and was made up of left ventricle. The epicardium was covered with an easily removable fine, granular, fibrinous exudate which was especially prominent over the base. The right atrium was roomy and the right AV orifice measured 10.0 cm. in circumference. The right ventricular wall was 0.5 cm. in thickness and was red brown and yellow. The pulmonary orifice

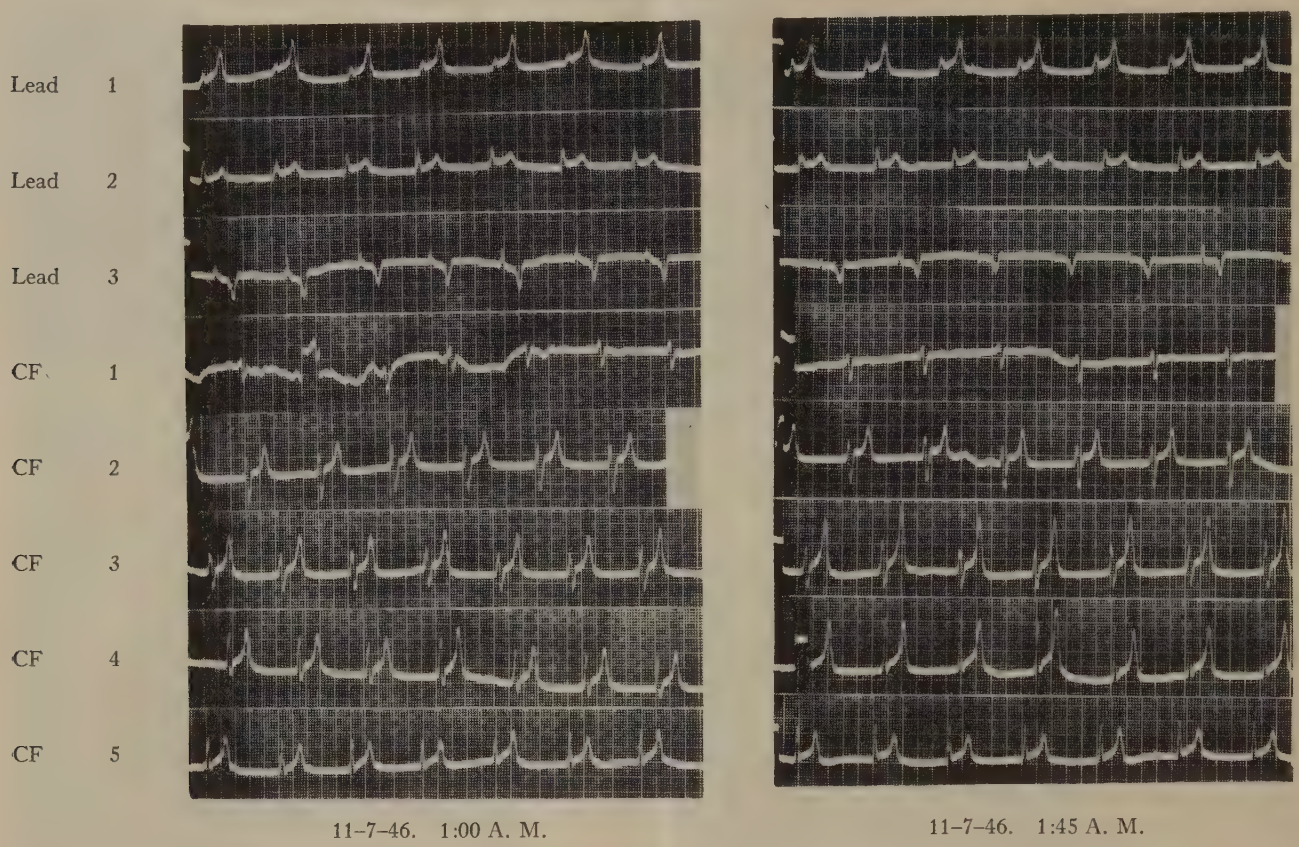

FIG. 2—A. Tracing taken 45 minutes after the administration of adrenal cortical extract and 10 cc. of calcium gluconate (10 per cent). P waves are still absent. B. Tracing taken 90 minutes after therapy. T waves are slightly higher in the chest leads

measured 7.0 cm. in circumference and the ductus arteriosus was closed. The left atrium was roomy and the foramen ovale was closed. The left ventricular wall was 1.6 cm. in thickness. The myocardium was red-brown streaked with gray. The papillary muscles were hypertrophied. The coronary arteries were patent and contained many intimal atheromatous plaques.

The external surfaces of the lungs were pink white mottled with black and on section were pale pink and homogeneous. The external surfaces were covered with a fibrous exudate.

The gastro-intestinal tract was not remarkable.

Together the adrenals weighed 22 grams. Their external surfaces were tan. On section the tan cortex was clearly demarcated from the brown medulla.

The right kidney weighed 120 grams. Its capsule stripped with ease. The external surface was pink gray, coarsely granular and contained numerous petechiae. On section the cortex could not be distinguished from the medulla and the color was pink gray with yellow streaking. The left kidney weighed 108 grams and was similar in all respects to the right kidney. The ureters were patent. The urinary bladder was not unusual.

The skull and cranial cavity were grossly normal. The brain weighed 1230 grams and was slightly edematous. The pituitary gland was not remarkable.

Microscopic Examination

Sections of the epicardium showed an increase in connective tissue and an infiltration by small round cells. Sections of the myocardium showed an increase in connective and adipose tissue.

Sections of the lungs revealed a focal pneumonia. There was a fibrinous pleuritis.

Examination of sections from the kidneys showed a thickened capsule. The glomeruli were numerous and unevenly distributed with a loss of cellularity. Many glomeruli were hyalinized. Bowman's capsule was thickened throughout with crescent formation in a few places. About many of the glomeruli and tubules there are many small round cells and the tissue is very vascular with many distended capillaries. The larger arteries showed eccentric intimal thickening. The smaller arteries showed thickened and hyalinized walls.

A congo red stain revealed amyloid to be present in the capillaries of the lungs; in the media of all the arteries in the portal spaces; in most of the peri-adrenal vessels and between the adrenal cortical cell cords; and in the glomerular tufts, the media of the smaller arteries and in the connective tissue of the medullary area (Fig. 5).

The following anatomical diagnosis was made. Primary: (1) pyelonephritis, acute and chronic, (2) amyloidosis in kidneys, adrenal glands, liver and lungs, (3) deformity of small joints of hands and feet, (4) pericarditis, fibrous, (5) focal pneumonia,

(6) fibrinous pleuritis, (7) edema of the brain, (8) fatty changes in the liver, (9) congestion of viscera. Secondary: (1) arteriosclerosis, generalized, marked, (2) fatty infiltration in pancreas and heart, (3) adhesive pleuritis and (4) fibrosis in pancreas and spleen.

Discussion

This patient on admission to the hospital exhibited the usual syndrome of the terminal stage in uremia. Because of the completeness of the renal failure there was probably an almost complete retention of potassium. Despite the confirmation of serum potassium levels, the electrocardiographic alterations are similar to those previously reported in clinically similar cases of uremia with high potassium blood levels (2, 3, 4). The myocardial lesions presented in this case are similar to others described in uremia. The electrocardiographic alterations, however, cannot be attributed to uremia and have only thus far been described in potassium intoxication. As seen in successive electrocardiographic tracings (Fig. 4), treatment directed towards the elimination of potassium succeeded in restoring a normal heart rhythm.

Normal potassium balance is maintained by a daily dietary intake and urinary excretion of about 3.4 grams. Renal clearance is low because of extrinsic tubular reabsorption and the kidney does not permit excessive loss of potassium in the urine. With a normally functioning kidney, the tubules reject potassium efficiently and promptly so that doses as large as 10 grams of potassium, given either orally or intravenously, may be excreted largely in the urine, small amounts in the feces, without significant changes in the blood potassium concentration. The urinary excretion of potassium and the concentration of potassium in the serum may be altered by both renal and extra-renal factors. The closer renal impairment approaches a total loss of renal function, the more apt it is to disturb the excretory ability of the kidney for potassium. Such a rapid renal failure may take place in acute, subacute, or congestive renal disorders; in chronic nephritis, especially in an acute exacerbation or in the terminal phase: and in amyloidosis of the kidney. Extra-renal factors such as dehydration, intestinal obstruction, excessive tissue catabolism—as seen in fasting and fevers: imbalance of adrenal-cortical factors; and changes in the complicated tissue balances of body fluid and tissue cells—all play a part in abnormally increasing the potassium blood level.

It was previously thought that because of the speed with which potassium was excreted by the kidneys it was not harmful in therapeutic doses. Human experiences rarely showed poisoning when potassium was administered. Several reasons account for this fact. The fasting clearance of potassium is not reduced in renal disease so that the basal excretion of potassium continues without in-

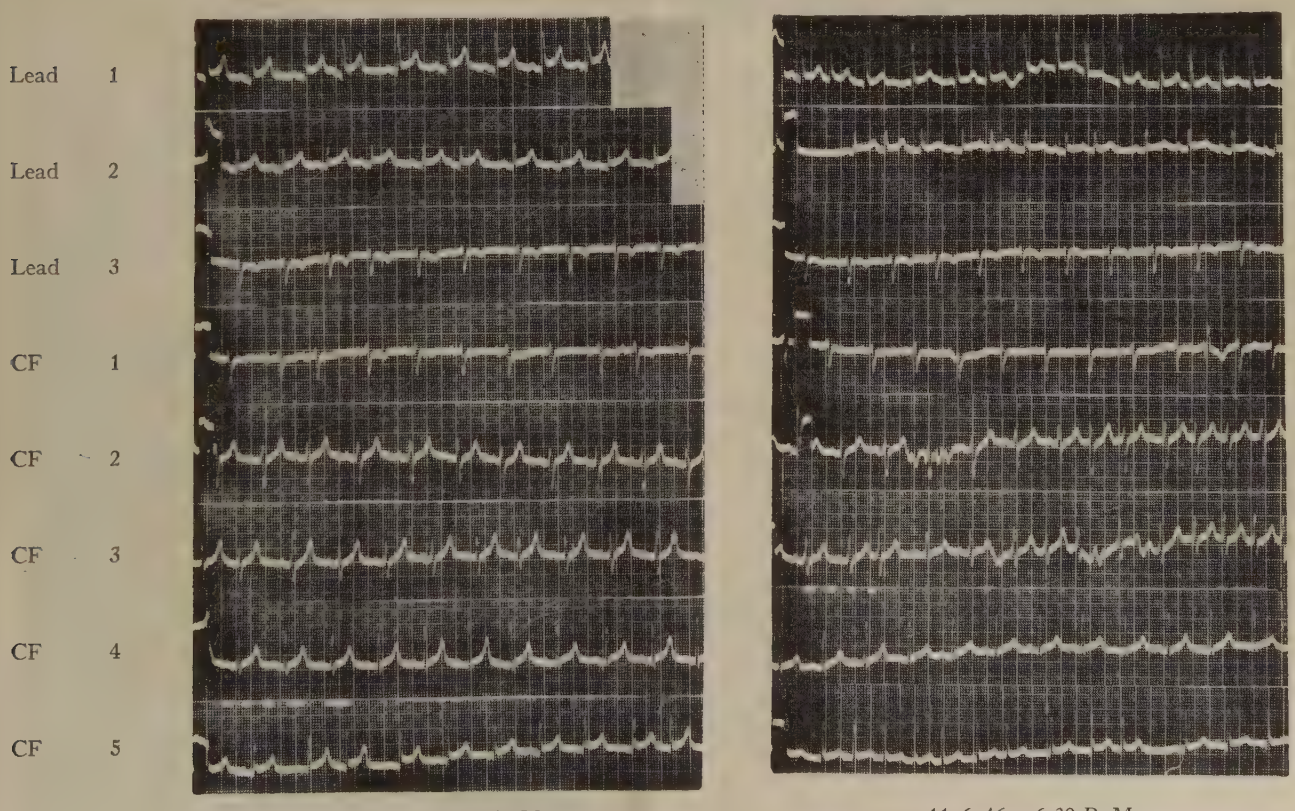

Fig. 3—A. Twelve hours after admission and eight hours after active treatment. Rate: 93 per minute. Normal sinus rhythm with premature auricular contractions. P-R interval: 0.16 seconds. QRS: 0.08 seconds. Left axis deviation. Elevated ST segments in Leads 1 and 2. T waves now normal. B. Approximate ventricular rate: 104 per minute. Normal sinus rhythm alternating with auricular fibrillation. P-R interval: 0.16 seconds. QRS: 0.08 seconds. ST segment and T waves normal

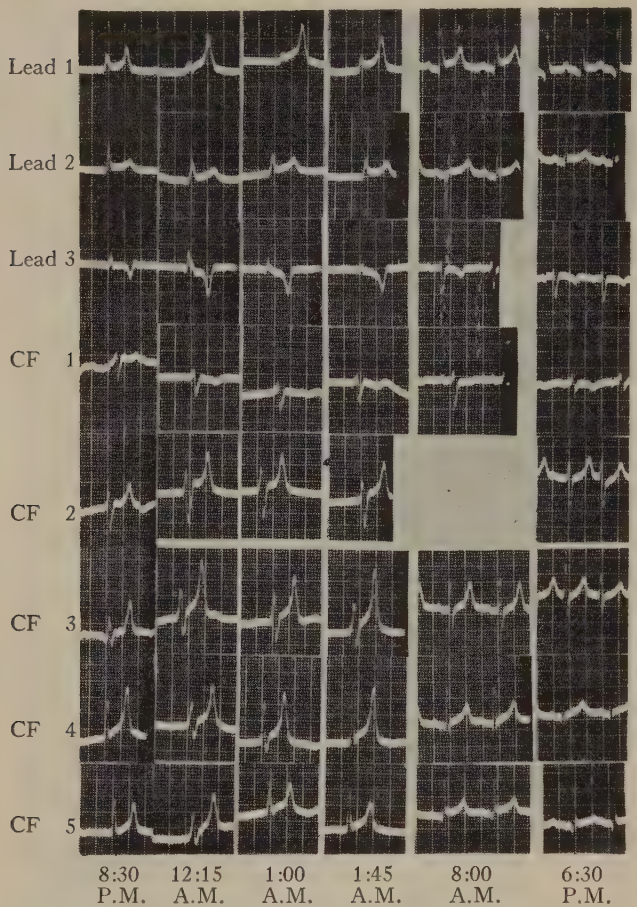

FIG. 4—Electrocardiograms showing progressive changes suggestive of potassemia and response to treatment

crease of potassium in the serum. The distribution of potassium ions beyond the confines of the extracellular fluid provides a temporary storage site for large amounts of potassium without much increase in serum concentration. Therefore potassium retention will not occur until severe oliguria or even anuria occurs since the most severely damaged nephritic kidney retains its ability to excrete potassium to the end. Despite a somewhat general feeling that an excess of potassium salts may be toxic, few experiments in man have been carried out. The work of Winkler (6) showed the toxicity of potassium salts when injected intravenously into dogs and when given orally to dogs whose ureters had been tied (7). These studies indicated that the electrocardiographic abnormalities encountered occurred concomitantly with increase in serum potassium levels. Further work by Thomson (8, 9) in man indicated that the increase in height of the T waves and the various degrees of heart block obtained could be directly ascribed to increased serum potassium levels.

These increased serum potassium levels produced in man associated electrocardiographic changes which have been shown to follow a typical sequence of events directly proportional to the potassium concentration of the serum (2). Sinus tachycardia is the simplest cardiac effect of an increase in potassium. Further changes are evidence of toxic effects on the sinus node and the specific conducting system of the heart giving rise to degrees of heart block ranging from prolongation of the P-R interval to complete A-V dissociation. As progression takes place intraventricular block occurs and finally auricular standstill. This absence of the P waves results from arrest rather than from auricular fibrillation, as is shown by the persistence of a regular rhythm. When the concentration of potassium rises sufficiently high, ventricular fibrillation occurs to be soon followed by death from ventricular standstill.

Moderate degrees of hyperpotassemia, with serum potassium levels of 5 to 7 meg/l., causes elevation of the T waves and it has been shown that the increase of serum potassium closely correlates with the increase in height of the T waves. Frequently the base of the T wave narrows and the apex becomes "peaked." S-T segment changes begin to occur at concentrations of 7.8 to 9.0 meg/l. The S-T segment is usually depressed, though it has been reported elevated in one case (10) and also in this present case. It changes in form, tends to shorten and may even be obliterated so that the T wave originates directly from the QRS complex. At a level of 9 meg/l. the P waves disappear. With a serum level of 9.5 to 10.5 meg/l. the QRS complex begins to spread. This may develop to an extensive intraventricular block, finally giving rise either to a diphasic curve or to a "W" shaped complex of low amplitude. The critical lethal value for man is supposedly 10 to 10.5 meg/l. and cardiac arrest definitely occurs at a concentration of 14 to

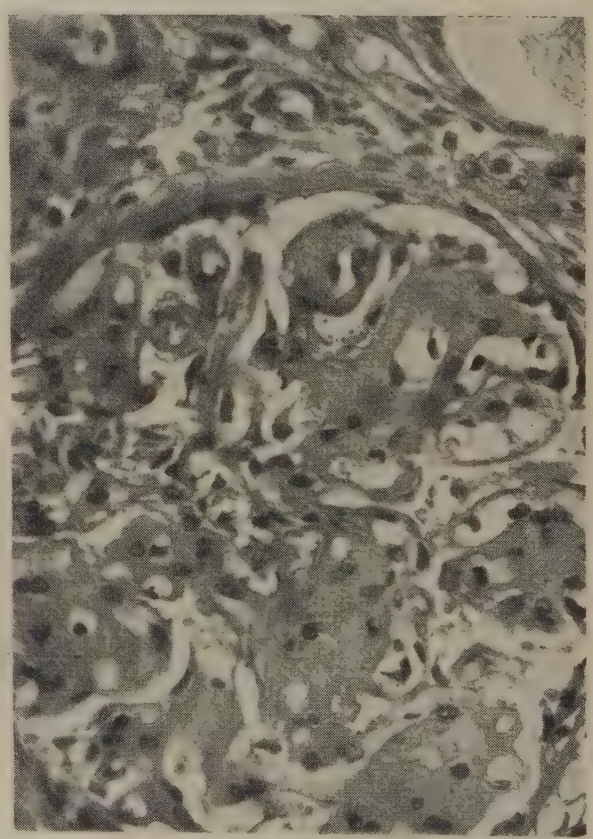

FIG. 5—Section of kidney showing hyalinization of glomeruli, thickened capsule with presence of amyloid. (Congo Red stain x 2255)

TABLE I—LABORATORY DATA

BLOOD

Date	HGB., gm. in 100 c.c.	W.B.C.	Urea, mg. in 100 c.c.	Creatinine, mg. in 100 c.c.	Uric Acid, mg. in 100 c.c.	Serum Potassium, mg. in 100 c.c.	CO_2 Combining Power, Vol. in 100 c.c.	Sugar, mg. in 100 c.c.	Sedimentation Rate (Westergren)
11/6			148			*	15		
11/7	12	16,950	144			*	48.4	166	110
			146	10.9	9.2	21.2	72.4		

* Laboratory accident.

URINE

Date	Specific Gravity	Volume, c.c. in 24 Hr.	Albumen	Acetone	Microscopic Sediment, Cells in H.P.F.
11/7	1.020	110	++++	None	40 WBC; 8 RBC
11/8	1.012	60	+++	None	Occ. WBC; many RBC
11/9		54			

16 meg/l. Many of the changes which occur at levels below 11 meg/l. are reversible with treatment, though survivals have been reported at higher levels.

In the treatment of potassium intoxication many factors must be considered, which, while distinct entities in themselves, are interrelated. These are primarily (1) adequate kidney function, since potassium balance can only be maintained by proper excretion in the urine, (2) correction of a disturbed electrolytic balance, (3) correction of an associated adrenal cortical deficiency and (4) correction of an associated low blood calcium level.

At first treatment should be directed both to stimulate kidney function and to establish a normal acid base equilibrium, production of efficient hydration and a normal water balance, and toward sustained establishment of a physiologic osmotic equilibrium. For this, sodium chloride, either as a physiologic solution or as the main component of Ringer's solution, is given, either intravenously or subcutaneously. This has a further advantage since there is evidence of a pharmacological antagonism between sodium and potassium ions (2). It may be followed by hypertonic glucose solution intravenously, which leads to deposition of glycogen in the liver. This process is accompanied by the retention of potassium and water, aiding in the removal of some of the potassium from the extracellular fluids.

Calcium, intravenously, is given to counteract the inhibitory effect of potassium on the heart. It is known that calcium affords some protection against ventricular fibrillation which occurs in high potassium serum levels (11) and against cardiac standstill. This possibly acts by increasing ventricular muscle irritability. Though the mechanism is unknown, increase in calcium blood levels is accompanied by a decrease in the potassium serum level (12).

In adrenal insufficiency the kidney fails to excrete potassium, so that in this condition the symptoms closely resemble those seen with toxic doses of potassium. Injection of adrenal cortical extract has been used with success in both conditions. This acts in lowering serum potassium by decreasing the excretion of sodium and increasing the excretion of potassium. There is also some evidence (12) of a definite effect of cortical extract upon potassium both in the kidney and in the tissues. Cortical extract also influences the retention of sodium in the kidney tubules.

Using these various methods of treatment of hyperpotassemia it is quite possible to obtain a reversible effect. It should not be forgotten that with this array of therapeutic procedures, both the clinical effect on the patient and the effect on the heart, recorded by frequent electrocardiographic studies, should be closely followed to determine the effect of the treatment.

SUMMARY

1. A case of uremia secondary to amyloidosis of the kidney is presented in which there was evidence of spontaneous accumulation of potassium in the serum following kidney failure.

2. Electrocardiographic changes consistent with potassium intoxication were noted. These consisted of elevated T waves, absence of P waves, intraventricular block and S-T segment depressions.

3. The treatment of hyperpotassemiais discussed.

The authors are indebted to Nathan Kreeger, M.D., for the pathological description.

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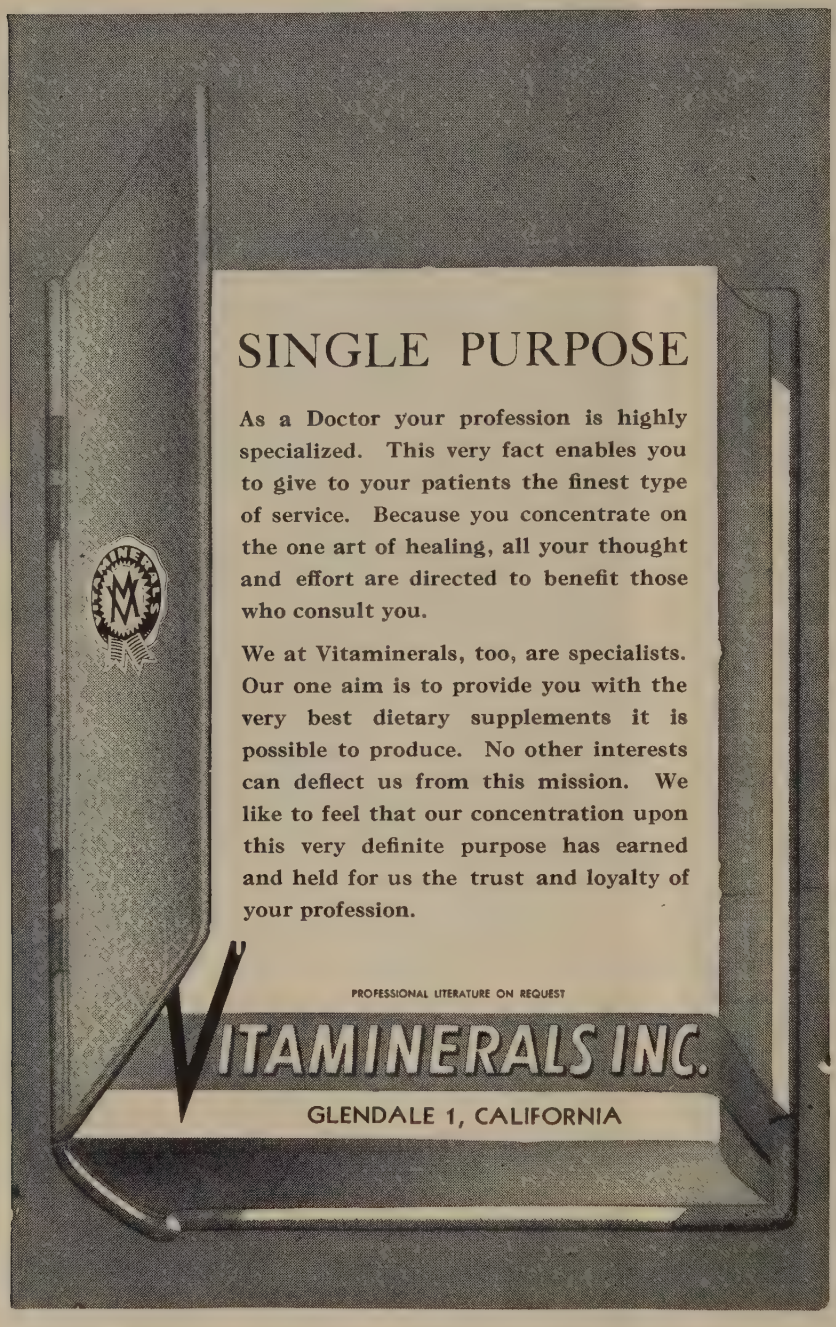
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The paper reviewed published data on seven anti-malarials—quinine, pemaquine, pentaquine, quinacrine (Atabrine), paludrine, and sontoquine.

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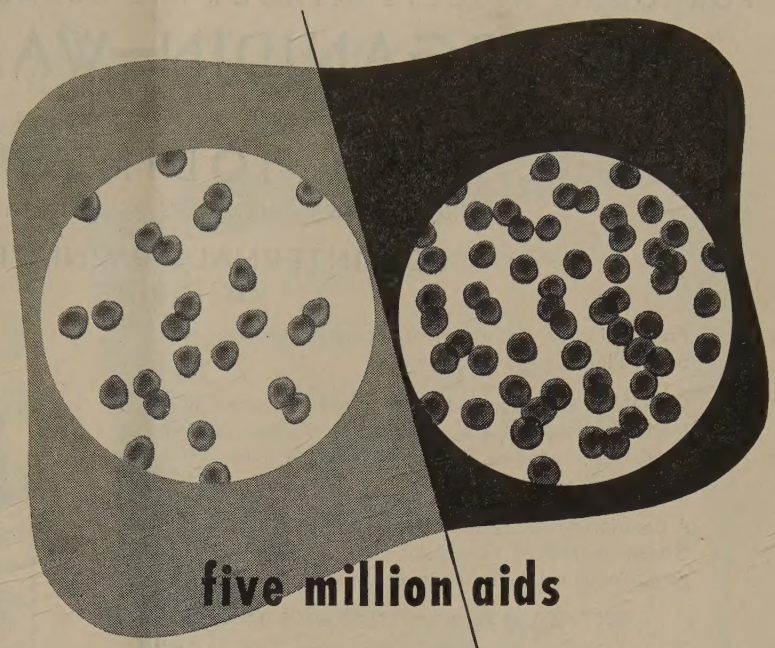

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